WHAT IS CLAIMED IS :

1. An apparatus for programmably generating an illumination pattern superimposed onto a substrate, said illumination pattern having a predetermined arrangement of light and dark zones, said apparatus comprising:

an illumination source;

a reconfigurable mask composed of an array of pixels, said pixels being actively controllable and directly addressable by means of a computer-controlled circuit and computer interface, said computer-controlled circuit being operated using a software program providing temporal control of the intensity of illumination emanating from each pixel so as to form the illumination pattern comprising the predetermined arrangement of light and dark zones;

a projection system suitable for imaging the reconfigurable mask onto the substrate; and

an imaging system incorporating a camera capable of viewing said substrate with superimposed illumination pattern.

2. The apparatus of claim 1, further comprising an image analysis system permitting acquisition of digitized images of the illumination pattern, analysis of said digitized images so as to extract feature vectors of interest, and thereby to permit creation of derivative patterns based on said feature vectors of interest.

3. The apparatus of claim 1, wherein said computer-controlled circuit and computer interface are capable of accepting input from a video display adapter.

4. The apparatus of claim 1, wherein said array of pixels is actively controlled so as to permit adjustment of variable and controllable levels of pixel transmissivity or reflectivity.

5. The apparatus of claim 4, wherein said array of pixels comprises a liquid crystal display or a digital micromirror device.

6. The apparatus of claim 1, wherein said software program provides a series of

illumination patterns, said patterns being produced interactively in a graphical user interface software program or being replayed from a storage device containing previously produced patterns.

7. The apparatus of claim 1, wherein the substrate comprises a light-sensitive planar electrode, said light-sensitive electrode being aligned with another planar electrode in substantially parallel arrangement, with said electrodes being separated by a gap, and the gap containing an electrolyte solution which is in contact with said electrodes and which contains colloidal particles suspended at an interface between the light-sensitive electrode and the electrolyte solution, and wherein the illumination pattern is projected onto said light-sensitive electrode so as to control the assembly and lateral motion of said colloidal particles, said assembly and lateral motion being induced by a time-varying electric field applied between said electrodes.

8. A self-tuning filter comprising:

a light-sensitive planar electrode that is aligned with another planar electrode in substantially parallel arrangement, with said electrodes being separated by a gap, and the gap containing an electrolyte solution which is in contact with said electrodes and which contains colloidal particles, wherein said particles are assembled in a planar array on the light-sensitive electrode, said array being composed so as to partially block incident light that controls array assembly in response to an electric field, and wherein the lateral density of said array self-adjusts in response to transmitted light intensity;

means for adjusting frequency of said applied electric field to a value lower than the characteristic dielectric relaxation frequency of said particles;

means for defining an illuminated area on said light-sensitive electrode; and

means for adjusting illumination intensity so as to induce assembly of said particles within the illuminated area.

9. The self-tuning filter of claim 8, wherein self-adjustment determines an optimal lateral density on attaining equilibrium which correlates with the transmitted light intensity of the frequency of the applied electric field.

10. A fractionation device for spatially separating and sorting a mixture of particles on a substrate comprising:

a substrate comprising a light-sensitive planar electrode, the light-sensitive electrode being aligned with another planar electrode in substantially parallel arrangement, with said electrodes being separated by a gap, and the gap containing an electrolyte solution which is in contact with said electrodes and which contains colloidal particles suspended in the electrolyte solution, said particles comprising a multiplicity of particle types exhibiting a differential frequency-dependent response to an applied electric field in accord with the respective characteristic frequency of each said particle type;

means for applying a time-varying voltage between said electrodes so as to generate a time-varying electric field and to induce the motion of said particles;

a means for adjusting frequency to a value less than the characteristic frequency of at least one particle type; and

a light-control component permitting illumination of a predetermined segment of the substrate with a predetermined intensity so as to induce collection into said illuminated segment of substantially all said particles of said at least one particle type having respective characteristic frequencies exceeding the frequency of the applied field.

11. The fractionation device of claim 10, wherein the particles are cells.

12. The fractionation device of claim 10, wherein the light-control component is a programmable illumination pattern generator.

13. The fractionation device of claim 10, wherein the particles may be collected into an illuminated segment being laterally scanned or reconfigured.

14. The fractionation device of claim 10, wherein the particles are separated based on differential-frequency response determined by particle size or by particle chemical composition.

15. An apparatus for programmably reconfiguring an array of particles on a substrate by programmable adjustment of an illumination pattern projected onto a substrate

comprising:

an illumination source;

a reconfigurable mask composed of an array of pixels, said pixels being actively controllable and directly addressable by means of a computer-controlled circuit and computer interface, said computer-controlled circuit being operated using a software program providing temporal control of the intensity of illumination emanating from each pixel so as to form the illumination pattern comprising the predetermined arrangement of light and dark zones;

a projection system suitable for imaging the reconfigurable mask onto a substrate, wherein the substrate comprises a light-sensitive planar electrode that is aligned with another planar electrode in substantially parallel arrangement, with said electrodes being separated by a gap, and the gap containing an electrolyte solution which is in contact with said electrodes and which contains colloidal particles suspended in the electrolyte solution; and

an imaging system incorporating a camera capable of viewing said substrate with superimposed illumination pattern.

16. A process for using a programmable illumination pattern generator so as to provide active feedback in the optimization of an illumination pattern prepared by said pattern generator, said process comprising:

creating a predetermined illumination pattern;

configuring programmable illumination pattern generator in accordance with said predetermined illumination pattern;

illuminating a field of view on a substrate using a light source and a projection system using the programmable illumination pattern generator;

acquiring an image of the field of view;

analyzing said image so as to extract a set of feature coordinates within the image; and

iterating said creating, configuring, illuminating, acquiring and analyzing steps n times, wherein n is an integer from zero to 10,000, using said feature coordinates determined in the (n-1)th analyzing step so as to create a derivative optimized illumination pattern.

17. The process of claim 16, wherein the predetermined illumination pattern is created within a graphical user environment.

18. The process of claim 16, wherein said configuration step is performed using a liquid crystal display panel.

19. The process of claim 16, wherein the programmable illumination pattern generator comprises an active mask which is configured by means of a video adapter interfaced with an active mask control circuit.

20. The process of claim 16, wherein the active feedback is used to programmably reconfigure an array of particles assembled on the substrate in accordance with claim 15.

21. The process of claim 20, wherein said particles are being reconfigured by applying a segmentation operation, said operation producing at least two subarrays.

22. The process of claim 16, wherein the active feedback is used to optimize the configuration of an assembled particle array by iterating the operation of array segmentation.

23. A flow control device for generating fluid flow comprising:

a light-sensitive planar electrode that is aligned with another planar electrode in substantially parallel arrangement, with said electrodes being separated by a gap, and the gap containing a fluid medium that is in contact with said electrodes;

means for applying a time-varying voltage between said electrodes so as to generate a time-varying electric field and to induce said fluid medium to undergo lateral flow;

means for adjusting voltage magnitude and frequency to preselected values to control flow velocity; and

a light-control component permitting illumination of a designated segment of the light-sensitive electrode, the combination of said time-varying electric field and illumination producing transverse fluid flow in accordance with the contour shape of the illuminated segment, said flow having a velocity component everywhere directed parallel to the surface and normal to the contour.

24. The flow control device of claim 23, said device being operated to generate a sequence of flow configurations.

25. The flow control device of claim 23, said device being operated so as to produce local flow fields in a configuration effecting the mixing of the fluid medium.

26. A process of programmably encoding a planar assembly of particles formed on a substrate by sequential injection of a multiplicity of groups of particles of at least one type, said process comprising:

providing a substrate comprising a light-sensitive planar electrode, the light-sensitive electrode being aligned with another planar electrode in substantially parallel arrangement, with said electrodes being separated by a gap, and the gap containing an electrolyte solution which is in contact with said electrodes;

placing a group of at least one type of particles selected from a reservoir containing said at least one type of particles into the electrolyte solution so as to confine said injected particles into a first segment of the light-sensitive electrode delineated by a first illumination pattern prepared using a programmable illumination pattern generator;

translocating said confined particles to a second segment of the light-sensitive electrode delineated by a second illumination pattern prepared using a programmable illumination pattern generator;

merging said particles with any pre-existing planar assembly of particles previously formed in said second segment of the light-sensitive electrode;

recording an image showing said translocated particles of said groups of particles in their final positions within said second segment; and

iterating the placing, translocating, merging and recording steps n times, wherein n is an integer from zero to about 10,000, so as to encode the array.

27. A process of decoding a planar assembly of particles encoded according to the process of claim 26, said decoding process comprising:

cross-correlating an image of the planar assembly with each of the images recorded at the completion of each placing, translocating and merging step.

28. A programmable patterning device for generating a chemically patterned surface or surface coating comprising:

an apparatus for programmably generating an illumination pattern having a predetermined arrangement of light and dark zones on said surface, the apparatus comprising:

an illumination source;

a reconfigurable mask composed of an array of pixels, said pixels being actively controllable and directly addressable by means of a computer-controlled circuit and computer interface, said computer-controlled circuit being operated using a software program providing temporal control of the intensity of illumination emanating from each pixel so as to form the illumination pattern comprising the predetermined arrangement of light and dark zones;

a projection system suitable for imaging the reconfigured mask onto the surface; and

an imaging system incorporating a camera capable of viewing said substrate with superimposed illumination pattern; and

a means for permanently altering a physical-chemical property of a light-sensitive surface or surface coating by exposure to light of pre-selected spectral composition in accordance with a programmed illumination pattern.

29. The device of claim 28, wherein the physical-chemical property comprises solubility in a pre-selected solvent so as to generate said chemically patterned surface or surface coating by exposure of the surface to said solvent.

30. The device of claim 28, wherein the physical-chemical reactivity comprises chemical reactivity so as to generate said chemically patterned surface or surface coating by subsequent functionalization of the surface by chemical reaction.

31. The device of claim 28, wherein the spectral composition contains the wavelength of the visible spectrum.